1155 Issued July 14, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 363.

THE USE OF MILK AS FOOD.

BY

R. D. MILNER, Ph. B.,

Assistant in Nutrition Investigations.

PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS,

A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., February 12, 1909.

SIR: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, an article on the use of milk as food, prepared by R. D. Milner, of this Office, which summarizes the results of numerous experiments carried on in connection with the nutrition investigations of the Office of Experiment Stations, as well as data gathered from publications of the agricultural experiment stations and general sources.

Perhaps no article of diet is more important than milk, and the present bulletin discusses such questions as composition, digestibility, care of milk in the home, use of milk in cookery, and its economy as compared with other foods. Some general information is also summarized regarding such milk products as butter, cheese, buttermilk, and whey.

The present bulletin is a revision and extension of an earlier Farmers' Bulletin, No. 74, "Milk as Food," which it is designed to replace.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

THE USE OF MILK AS FOOD.

INTRODUCTION.

According to the census of 1900, about two-thirds of all the milk produced for sale by the farmers of the United States was used to make butter and cheese, while the remaining third was consumed directly as milk and cream. The figures given showed that on the average each person in this country consumed about 20 gallons of milk a year, or that each family of five used about 1 quart a day. According to estimates of the Bureau of Animal Industry of this Department, the average annual consumption in 1903 was about 30 gallons per person. This Department has previously published bulletins which discuss the various phases of the milk question as they appear to the farmer who produces it, the dealer who distributes it, and the manufacturers of butter and cheese. The purpose of the present article is to consider the question of milk as a food from the point of view of the consumer, to show why it is a valuable part of his diet, and under what conditions it is most valuable. The importance of such a consideration is indicated by the fact that milk and cream together furnish 16 per cent of the total food of the average American family.

Questions pertaining to the care and management of dairy cows, the effect of different systems of feeding on the yield and quality of milk, the distribution and marketing of milk, the manufacture of butter, cheese, and other dairy products, and related questions have been studied at the agricultural experiment stations of the United States and elsewhere. The Dairy Division of the Bureau of Animal Industry of this Department has carried on extensive investigations of a great many problems of milk and its products, and to their work much of the data at present available may justly be attributed. The study of the digestibility and nutritive value of milk and its products has formed a part of the cooperative nutrition investigations carried on under the auspices of the Office of Experiment Stations, and many facts which are of interest and importance have been secured. In the following pages information drawn from this and similar sources has been summarized.

SOURCES AND KINDS OF MILK.

In civilized countries where the climate allows, cows have been most generally bred for the purpose of giving milk, probably not so much because their milk was more particularly desirable for human food than that of some other mammals as because, all things considered, they can be made to give the best results for a given amount of care and feed. Our preference for their milk is undoubtedly the result of habit and acquired taste rather than of any intrinsic superiority, save, of course, as special breeding has developed certain desirable characteristics. In some parts of the world other kinds of milk are used; goat's milk is very common, especially in the rough, hilly districts of Europe; buffalo's milk is much used in India, and llama's milk in South America, while camel's milk is esteemed in desert countries, and mare's milk on the steppes of Russia and Central Asia. Sheep's milk is used in Europe and elsewhere for making certain kinds of cheese and in other ways, and the milk of reindeers is commonly used as food in the arctic regions. So much does cow's milk predominate in the western world, however, that unless otherwise specified the word milk almost always refers to that kind.

Perhaps no food has been more often studied by chemists than milk and its products, and so a great deal of information is available regarding the composition and properties of these important food materials.

The average composition of cow's and some other kinds of milk used for food is given in the table which follows:

Average composition of milk of various kinds.

Kind of milk.	Water.	Total solids.	Protein.			Fat.	Carbohydrates (milk sugar).	Mineral matters.	Fuel value per pound.
			Casein.	Albumin.	Total.				
	Per cent.	*Per ct.*	*Per ct.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Woman	87.58	12.6	0.80	1.21	2.01	3.74	6.37	0.30	310
Cow	87.27	12.8	2.88	.51	3.39	3.68	4.94	.72	310
Goat	86.88	13.1	2.87	.89	3.76	4.07	4.64	.85	315
Sheep	83.57	16.4	4.17	.98	5.15	6.18	4.73	.96	410
Buffalo (Indian)	82.16	.....	4.26	.46	.....	7.51	4.77	.84	.....
Zebu	86.13	.....	.....	.....	3.03	4.80	5.34	.70	.....
Camel	87.13	.....	3.49	.38	.....	2.87	5.39	.74	.....
Llama	86.55	.....	3.00	.90	.....	3.15	5.60	.80	.....
Reindeer	67.20	.....	8.38	1.51	.....	17.09	2.82	1.49	.....
Mare	90.58	9.9	1.30	.75	.....	1.14	5.87	.36	.....
Ass	90.12	10.4	.79	1.06	.....	1.37	6.19	.47	215

As the figures in the table make plain, milk of all sorts is a dilute food, as it contains a large percentage of water, the lowest proportion according to the figures cited being noted with reindeer milk and the highest with mare's milk. The three groups of protein, fat, and

carbohydrates are represented by fair proportions, the quantities of protein and fat being especially noteworthy, as it is these constituents and the mineral matter or ash which to a large degree give milk its peculiar value as a food for young mammals.

COMPOSITION AND CHARACTERISTICS OF MILK.

In the discussion of the composition and characteristics of milk which follows, reference is made almost exclusively to cow's milk, as this is the only kind which is especially important in diet in the United States, at least after infancy. From the large number of analyses of milk and milk products which have been reported by the agricultural experiment station chemists and other investigators the following data showing the average composition of these materials have been compiled. The table also includes, for purposes of comparison, the average composition of a number of other common food materials.

Average composition of milk products and other food materials.

Material.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Whole milk	.....	87.0	3.3	4.0	5.0	0.7
Skim milk	.....	90.5	3.4	.3	5.1	.7
Cream	.....	74.0	2.5	18.5	4.5	.5
Buttermilk	.....	91.0	3.0	.5	4.8	.7
Whey	.....	93.0	1.0	.3	5.0	.7
Condensed milk, unsweetened	.....	71.3	7.4	8.5	11.1	1.7
Condensed milk, sweetened	.....	26.0	8.2	9.6	54.3	1.9
Butter	.....	13.0	1.0	83.0	.....	3.0
Cheese, American Cheddar	.....	33.5	26.0	35.5	1.5	3.5
Cheese, cottage	.....	53.0	19.6	23.2	2.1	2.1
Cheese, Swiss	.....	31.4	27.6	34.9	1.3	4.8
Milk powder (from skimmed milk)	.....	3.0	34.0	3.1	51.9	8.0
Kephir	.....	89.6	3.1	2.0	[a] 4.5	.8
Koumiss	.....	90.7	2.2	2.1	[b] 4.1	.9
Infant and invalid foods, farinaceous	.....	9.4	9.4	.4	[c] 79.9	.9
Infant and invalid foods containing milk and starches	.....	4.3	9.6	3.8	[d] 80.2	2.1
Infant and invalid foods, malted preparations	.....	4.2	12.0	1.0	[e] 79.8	3.0
Beef, sirloin steak	12.8	54.0	16.5	16.1	.....	.9
Eggs, as purchased	11.2	65.5	11.9	9.3	.....	.9
Wheat flour, patent roller process	.....	12.0	11.4	1.0	75.1	.5
Wheat bread, white	.....	35.3	9.2	1.3	53.1	1.1
Beans, baked	.....	68.9	6.9	2.5	19.6	2.1
Potatoes, as purchased	20.0	62.6	1.8	.1	14.7	.8
Apples, as purchased	25.0	63.3	.3	.3	10.8	.3

[a] Including 2.1 per cent alcohol and 0.8 per cent lactic acid.
[b] Including 1.7 per cent alcohol and 0.9 per cent lactic acid.
[c] Including 6.62 per cent soluble carbohydrates (sugars).
[d] Including 49.05 per cent soluble carbohydrates (sugars).
[e] Including 48.39 per cent soluble carbohydrates (sugars).

Milk as it is drawn from the cow is familiar to all as an opaque, whitish liquid, which varies considerably in appearance and in flavor. It is commonly described as consisting of a thin, bluish-white, somewhat transparent liquid, called the plasma, in which are floating yellowish globules of fat so numerous and so well distributed that the whole appears to be a white fluid. The chief bulk of milk is water,

the amount of which may vary, even in ordinary unadulterated milk, from 90 per cent in a very poor product to 84 per cent in an unusually rich milk, the average being, as appears from the data in the table, about 87 per cent. The corresponding solid matter varies from 10 to 16 per cent. This solid matter, or "total nutrients," is made up of protein, fats, carbohydrates, and mineral matter. The proportion of these vary within certain limits; but, roughly speaking, one-twentieth of the total solids are mineral substances, one-fourth protein, three-tenths fat, and four-tenths carbohydrates, as the above table shows.

THE PROTEIN COMPOUNDS OF MILK.

Protein compounds are the important nitrogenous ingredients which are indispensable in the formation of body tissues and fluids; they may also be burned in the body to furnish energy, their fuel value being about equal to that of the carbohydrates and less than half as great as that of the fats.[a] Protein is found in different forms, such as the white of egg (egg albumin), the lean of meat (myosin), the legumin of peas and beans, etc. In milk the principal protein compound is casein. In chemical composition the casein differs from the other protein compounds of milk in that it contains both phosphorus and sulphur. When acid is added to a solution of this casein, it is precipitated in light, white flakes, such as are seen in sour milk. If, however, an alkali such as limewater is also added to neutralize the acid, these curds do not form or are redissolved. Another kind of precipitation or curdling of the casein occurs when rennet is added, as in cheese making. The ferment rennin, which is present in rennet (and also in human gastric juice), throws down the casein, but into a tougher and less flocculent or flaky mass than the acid, and one which can not be redissolved by the addition of an alkali. Besides the casein there is a certain amount of albumin present in milk, sometimes called lactalbumin, but the quantity is very much smaller than that of the casein, being on the average about one-seventh of the total protein. The proportion of albumin to casein varies in the milk of different kinds of animals and also in the milk of a single cow. There are other nitrogenous substances occurring in milk, but in such small quantities that they need not be considered here.

The total protein of milk should not vary in any great degree, and will average not far from 3.3 per cent of the whole milk, or about 25 per cent of the total solids.

[a] The fuel value of any substance is artificially determined by burning it in a bomb calorimeter and measuring the heat given off. The unit of measure is a calorie, which represents the amount of heat necessary to raise the temperature of 1 pound of water 4° F. One pound of protein or carbohydrates has a fuel value of 1,820 calories, and 1 pound of fats 4,040 calories.

THE FATS AND CARBOHYDRATES OF MILK.

The fat of milk is commercially the most important of its constituents, since it is the source of butter and enters largely into the composition of cheese. It is found throughout the milk in globules, varying in size in the milk from different animals, which, being lighter than water, tend to rise to the top of the milk as it stands, forming the cream. Chemically speaking, the fat of milk, commonly called butter fat, consists of several different fats, the chief of which, called stearin, palmitin, and olein, are the same as those that make up the bulk of meat fat (tallow, lard, etc.), as well as of many vegetable fats. The amount and quality of fat in milk varies widely, for reasons which are mentioned later. The amount should not fall below 3 per cent, and except in unusually rich milk will not exceed 5 per cent. It averages about 4 per cent of the milk, or about 31 per cent of the total of solids.

The chief carbohydrate which occurs in milk is lactose or milk sugar. It is similar in chemical composition to cane sugar, but is not as readily soluble, and this is one reason at least why it does not taste as sweet, though tests made with solutions show that cane sugar is markedly superior as regards this property. It may be obtained in crystals, but milk sugar is usually marketed as a fine white powder much like confectioners' sugar in appearance, and is largely used by pharmacists and physicians as a vehicle for drugs in the manufacture of powders, pills, tablets, etc. The amount of milk sugar in cow's milk varies from 4 to 6 per cent, the average being about 5 per cent of the total milk, or 38 per cent of the total solids.

The milk sugar remains in the whey when casein or curd is removed in cheese making, and may be readily recovered. The manufacture of milk sugar from whey is an important industry.

MINERAL MATTERS IN MILK.

The ash constituents in milk consist mainly of the phosphates and chlorids of soda, potash, and lime. Most of these are dissolved in the plasma, but tiny particles of the phosphates of lime remain undissolved, and are said to be a cause of the bluish tint found in milk. The mineral matters make up about seven-tenths of 1 per cent of the whole milk or 5 per cent of the solid matter. Along with these principal ingredients milk also contains minute quantities of other substances, some of which will be referred to later.

BACTERIA IN MILK.

Besides the chemical compounds, milk also contains large numbers of minute organisms called bacteria. Few, if any, are normally

present in the milk within the udders of clean, healthy cows, but they are so abundant everywhere in the air, especially about the stable and barnyard, and cling in such numbers to the bodies of the cows, that they are almost always found in milk as soon as it leaves the udders or even just inside the teats. They reproduce very rapidly in a favorable medium, such as warm milk, so that the number present becomes very large unless measures are taken to hinder their increase. The amount in milk of a given age of course varies with the conditions; that from clean cows, with freshly washed udders, milked into well-scalded pails, in a clean place, free from air currents, by persons with clean hands and clothes, and quickly cooled and carefully handled, may contain very few, while milk from ill-kept animals untidily handled in a dirty place may contain enormous quantities. Since, as will be shown later, bacteria cause the spoiling of milk, and may be harmful in other ways, it is very evident that scrupulous cleanliness about everything which comes in contact with the milk is of first importance.

A great many kinds of bacteria have been found in milk, each of which occasions a special set of changes as it develops. Perhaps the most important kinds are those which cause the ordinary souring of milk and are the first to produce any noticeable change in the taste and odor. In their growth they feed upon the milk sugar and convert it into lactic acid, which gives slightly soured milk its peculiar taste and odor. When enough of this lactic acid has formed it acts upon the casein, causing it to separate into loose, light flakes such as we see in ordinary sour "lobbered" milk. Other bacteria may also develop in sour milk which give it a strong, unpleasant odor or flavor. Some of the products of bacterial action on milk are desirable—for instance, those which give to butter and cheese the characteristic flavors and odors. Still others occasionally appear in milk which color it very brightly or give it a slimy or ropy consistency. Milk sometimes sours more quickly than ordinarily when there is a thunderstorm. This is often said to be due to electricity in the air, but bacteriologists claim that it is due to the hot, damp atmosphere which usually precedes the storm, as the heat is especially favorable to the growth of bacteria.

SPECIFIC GRAVITY AND FREEZING POINT OF MILK.

Milk is slightly heavier than water, its specific gravity ranging from 1.029 to 1.034 at 60° F. This means that while a quart of water weighs 2 pounds 1.333 ounces, a quart of milk weighs from 1.029 to 1.034 times as much, or not far from 2 pounds 2.5 ounces. The specific gravity depends upon the proportion of water and other substances. Since the fat is lighter than water, the richer the milk is in

butter fat the lower its specific gravity, provided, of course, that the other solids are not increased proportionally. It follows also that the removal of the fat increases the specific gravity, so that skim milk has a specific gravity of from 1.033 to 1.037. On the other hand, the addition of water to skimmed milk brings down the specific gravity. The freezing point of milk also varies with the composition, falling as the proportion of solids increases and rising if water is added. In average milk it is about 31° F. This factor is of importance in judging of the purity of milk.

VARIATIONS IN MILK.

The milk which is ordinarily sold for household use is subject to considerable variation in composition, and it is entirely possible for one man to pay nearly twice as much as his neighbor for an equivalent nutritive value in milk at the same price per quart but from different dealers. It is owing to such natural variation in composition that milk is purchased at creameries on the basis of its fat content. (See p. 19.) This variation in nutritive value is in large part attributable to differences in the breeds of cows kept, certain breeds producing milk which contains more fat than others. Among the best for producing cream are the Channel Islands breeds, which give a milk rich in large fat globules, that rise easily to the surface. For general purposes, however, breeds which yield milk containing fairly good proportions of all the ingredients of the solids are considered more desirable. The age of the animal also has considerable influence, young cows producing richer milk than old ones of the same kind. In general a well-fed cow gives more and better milk than if poorly fed, but the relative proportions of fat, casein, and sugar in the milk are not so greatly influenced by the composition of the food as is the quantity of milk. The average cow of a given breed possesses certain capabilities for producing milk, but does not reach her normal capacity of milk production unless she is well fed. When once she has a sufficient and well-balanced ration, neither the composition nor the amount of the milk yield seems to be greatly improved by either increasing the ration or changing the proportion of the nutrients it supplies.

The milk flow of a given cow is usually largest soon after calving; as the period of lactation progresses the milk flow gradually falls off, and, as a rule, the milk grows richer, i. e., the proportion of solids increases. The proportion of fat to the other solids in the milk of a given cow varies from day to day and from milking to milking.

On account of all these variations in the milk of individual cows, dairymen who supply the milk trade usually find it best to mix the milk from all the cows in the herd immediately after it is drawn.

This is of considerable advantage to the consumer, as it makes the milk much more uniform from day to day.

A cause of variation in milk is found in the adulteration not infrequently practiced by unprincipled producers or dealers. The chief methods of adulteration aside from the use of chemical preservatives are the addition of water and the removal of a portion of the fat, both methods being often used together. These methods are not only fraudulent as regards money value, but also diminish the food value. The specific gravity of the milk is sometimes used as a test of its purity, but since removing part of its fat in the form of cream raises and adding water lowers the specific gravity, one form of adulteration may cover up the other, and thus render this test alone unreliable. A similar difficulty is found in testing milk by its freezing point, which varies with the proportion of the different soluble constituents.

FLAVOR.

The flavor of milk varies almost as much as its composition. It is in part due to the amount of fat present, but also to the number and kind of bacteria, or rather to the product of bacterial action. The flavor is also often influenced by the food of the cow; this is especially noticeable when the cows have eaten some strong-tasting substance, such as turnips, and is due to the fact that the volatile oil or other flavor of the food passes directly through the animal tissues into the milk. Milk also absorbs flavors and odors from the air much more quickly than most foods. The "animal" or "cowy" taste and smell, which are often noticeable in new milk, are believed to be due in part to this absorption. It may also be due in part to stable dirt which accidentally falls into the milk. The cleaner the animal the less noticeable is this taste in milk. It may be considerably lessened by promptly cooling and aerating the milk after it is drawn.

A pan of milk kept in a closed ice box with fish or high-flavored vegetables or fruit is very likely to acquire flavor and odor from them; hence milk should be kept where the air is free from such taint.

DIRT IN MILK.

There is frequently more or less dirt in freshly drawn milk, most of it fine particles of litter and manure which fall into the pail from the body of the cow. Milk should always be strained directly the milking is over, or, better still, it should be drawn into pails covered with straining cloths; but even with these precautions some dirt may be present. Of course, the amount varies with the condition in which the cow and her surroundings are kept; under ideal dairy conditions only very small quantities are found, while milk from untidy estab-

lishments may contain enough in a quart to form a noticeable sediment. Milk with enough dirt to be visible indicates a badly kept dairy and should not be tolerated, and consumers should always insist upon having clean milk. It should be remembered that the visible dirt does not tell the whole story; some of the manure that falls into milk is dissolved, and is no longer noticeable to the eye.

If milk is measured out from a large can at the door of each customer dust and dirt from the street as well as bacteria may get into it. The custom of delivering it in sealed bottles is much neater and has the further advantage of giving the buyers more uniform amounts of cream than where some get the top and some the bottom of the milk taken from a large can.

MILK AS THE POSSIBLE CARRIER OF DISEASE.

Disease germs may get into milk either directly from a diseased cow or indirectly from an infected person, from polluted water, or in some similar way. The most dreaded disease which may come directly from the cows is tuberculosis. It is certain that the tubercle bacillus, the germ which causes the disease, does sometimes exist in milk from tuberculous animals; whether or not persons who drink such milk may become infected by it is extremely hard to prove. There are many other possible sources of contagion, and the disease develops so slowly that by the time it is recognized it is usually too late to trace the cause. Nevertheless, there is quite enough evidence that the disease may be carried in this way to make the use of milk from tuberculous cows too dangerous to be tolerated, even when the animals are only slightly diseased. Among the contagious diseases to which the cows are not liable but which may be spread by milk the most common are perhaps scarlet fever, typhoid fever, and diphtheria. Statistics show that milk is very often the cause of an epidemic of such contagious disease, and not infrequently a serious epidemic may be traced to the milk from a single farm. The bacteria causing these diseases frequently enter the milk from contaminated water used in washing milk utensils, etc., or from persons who have been exposed to disease and who handle the milk. For this reason no water which is not above suspicion should be used about the dairy (or anywhere else) for either drinking or washing, and no person who has been exposed in any way to such diseases should be allowed about the cows, the milk, or the milk utensils.

PRESERVING MILK.

If milk could be obtained and kept free from bacteria it would probably remain sweet almost indefinitely. How near to this ideal it is possible to come may be seen from the fact that milk from several

American dairies exhibited at the Paris Exposition in 1900 was sweet when over two weeks old, no method of preservation being followed except cleanliness and keeping it at a temperature of 40° to 42° F. According to more recent data, published by the Bureau of Animal Industry of this Department, clean milk may be kept five to seven weeks.[a] The conditions which make such milk possible are still uncommon, but they are becoming and will continue to become more common as consumers realize that it is worth the extra cost which the necessary carefulness entails. At present, however, it is often necessary to find some means of checking the growth of the bacteria. Besides the various methods of drying milk, which will be discussed later (see p. 18), there are three means of accomplishing this: (1) By cold, (2) by heat, and (3) by the use of chemical preservatives.

COLD.

Low temperature, even when extreme, does not of itself kill bacteria, but any temperature below 50° F. makes them more or less inactive for the time being. Occasionally milk is preserved by freezing, but this is undesirable because the character of the ingredients is slightly altered by the process. The changes begin at about 35° F., and milk should not ordinarily be kept at a lower temperature than this. Down to that point, however, the cooler the milk the better it keeps. As has been suggested, milk should be cooled as soon as it is drawn, in order that bacteria, whose growth is very rapid, may not make too much headway in the warm liquid.

HEAT.

Slight warmth is very favorable to the growth of bacteria, but great heat is fatal to them. Unfortunately, heat sufficient to destroy all the varieties also causes changes in the chemical composition and flavor of the milk, as seen in boiled milk; otherwise cooking milk would be a very simple and satisfactory way of preserving it. When heat is used, it is well to apply it in such a way as to do the most damage to the bacteria with the least damage to the other materials. The two most common methods are pasteurization and sterilization. These terms are often used interchangeably, but they really refer to distinct processes.

In pasteurizing milk the aim is to destroy as many bacteria as possible without producing any of the changes in the chemical constituents which take place when the milk is heated and which begin at about 167° F. Experience has shown that the temperature of milk during pasteurization should not exceed 185° F. nor fall below

[a] U. S. Dept. Agr., Bur. Anim. Indus. Circ. 117.

140° F. To pasteurize milk it may be placed in air-tight bottles or bottles which are stoppered with sterilized cotton, and immersed to the neck in hot water and heated, for instance, at 149° F. for a half hour or at 167° F. for fifteen minutes, and then quickly cooled to 50° F. or less. This rapid cooling lessens the "cooked" taste so objectionable to many persons.

Sterilized milk, on the other hand, is milk subjected to heat sufficient to destroy all the organisms in it. It is not always accomplished by simply boiling the milk unless the boiling is repeated on two or three successive days. Higher temperatures than the boiling point are necessary to assure sterilization or the complete destruction of all organisms at one application of heat of fifteen to thirty minutes' duration. For many practical purposes, however, simply raising the milk to the boiling point is sufficient. Much of the so-called "sterilized milk" has been thus treated and is by no means free from living organisms. Sterilized milk will remain sweet in a warm place longer than pasteurized, but the greater heat produces more of the undesirable chemical changes. Both pasteurized and sterilized milk should be kept in clean, air-tight bottles or new bacteria will enter and begin their destructive work.

Pasteurized milk can now be obtained in many large milk depots; but under ordinary conditions housekeepers usually prefer to buy fresh milk and do their own heating when necessary. Pasteurized cream is frequently sold, but is considered less desirable than fresh. It seems thinner and does not "whip" well (see p. 39). These differences do not necessarily mean that the pasteurized cream contains less fat than the fresh, but that the heat has somewhat changed the character of the fat globules.

CHEMICAL PRESERVATIVES.

These are substances put into milk to kill or hinder the growth of bacteria by chemical means, a practice which is forbidden by the pure-food legislation which has been enacted in many States. The most common are borax, boric acid, salicylic acid, formalin, and saltpeter. There are several decided objections to their use, the most important being that they may seriously injure the health and that they help to conceal dirt with the accompanying bacteria. Although an occasional small dose may not be harmful, the consensus of opinion is that, taken continuously, such preservatives retard digestion and have an irritating effect on the intestines, often causing serious disturbances. They are of course most dangerous to the delicate organs of infants and invalids, who are also the most dependent on milk for nourishment. Moreover, while they kill many microorganisms, they do not kill all; some of the most dangerous, such as

the tubercle bacilli, have been known to resist considerable quantities. Finally, they are so often employed to make old milk pass for fresh, or dirty milk for clean, that their use in ordinary milk suggests a dishonest or a dirty milkman.

CONDENSED MILK AND MILK POWDER.

When milk is heated the water in it evaporates readily, and if the heating is continued long enough, as, for instance, in making the well-known pudding of rice and milk, cooked slowly in the oven for a long time, the milk becomes thick and creamy. In the case of the pudding the thickening is due in part, of course, to the effect on the starch of the rice, but also in considerable measure to the elimination of water from the milk. This fact is taken advantage of in the manufacture of evaporated or condensed milk. On a commercial scale the process is commonly carried on in vacuum pans, as under such conditions a lower degree of heat may be employed and the danger of scorching is lessened. Sugar is very commonly added to condensed milk, though unsweetened condensed milk is also a common commercial product. Such unsweetened milk evaporated to about the consistency of cream was formerly sold under the name evaporated cream. Condensed milk is ordinarily marketed in cans of varying size and its manufacture is an enterprise of very great importance. Its low water content and large percentage of sugar do not favor bacterial growth, and so it will keep for a reasonable time after the cans are opened. Condensed milk is used in many ways like fresh milk or cream. When properly diluted with water it may be used in cookery like ordinary milk and is very satisfactory for the purpose, especially on shipboard, in the Tropics, or elsewhere where fresh milk can not be readily obtained. The small bulk is an additional advantage in shipping. Condensed milk is used to a large extent for infant feeding, and has the advantage of being sterile, but it is not considered so satisfactory as fresh milk or as pasteurized milk. Investigations have shown that with children and adults condensed milk has practically the same coefficients of digestibility as fresh milk.

Within recent years special devices have been put on the market for evaporating milk to a fine flour-like powder, which is easy to keep, nutritious, and, of course, convenient for shipment. When water is added the resulting mixture closely resembles ordinary milk in appearance and may be used in cookery and in other ways. The flavor depends to a great extent upon the method of manufacture, in some cases being almost the same as that of fresh milk, while in other cases a slightly strong or scorched taste is present, but is not pronounced enough, it is said, to be noticeable in cooked products in which it is used.

The relative amount of nutrients in milk, condensed milk, powdered, dried, skim milk, and other milk products, is shown in the table on page 9 and graphically in the charts on pages 30 and 37.

GRADED AND CERTIFIED MILK.

There is so much difference in the composition of milk that many large butter and cheese factories now test all the milk which they buy and pay for it according to the amount of fat which it contains. The importance of such an arrangement for the retail milk trade is evident.

The terms "standardized" milk or "blended" milk are applied to milk which has been so modified as to contain a definite amount of one or more of its constituents. The most important and at the same time the most variable constituent is fat. To standardize milk as regards fat it is only necessary to add or remove a certain amount of this constituent or to add or remove a certain amount of skimmed milk. Directions for such standardizing or blending have been summarized in an earlier publication [a] of this Department. Most States and cities now have a legal standard for milk, representing a fair amount of fat and other solids.

If all milk sold could be tested by such a standard, and the price regulated according as the milk surpassed or fell below it, both producer and consumer would be better satisfied, the producer because he would get credit for good milk, and the consumer because he would know what he was really buying. Such graded milk is sold in some European cities, and to a less extent in this country. The principle has been more commonly applied to cream, of which different qualities are sold at prices varying with the amount of fat.

In some of our large cities what is known as "certified" milk may be obtained. The dealers' certificate is usually in the form of a label pasted over the top of the bottle. Under local pure-food laws the use of this label is permitted only to those establishments which are periodically inspected by public officials as to their sanitary conditions, and which market milk conforming in composition to a fixed standard. Such milk justly commands a higher price than that of which the quality is not guaranteed.

The term "sanitary" milk is quite commonly used, being applied somewhat indefinitely to milk produced and handled under conditions considered necessary to secure a pure, wholesome product. It is often applied by dealers, for purposes of advertising, to milk produced under decidedly insanitary conditions. The term "hygienic" milk is similarly abused.

[a] U. S. Dept. Agr., Farmers' Bul. 281.

When milk is passed through a centrifugal separator much of the solid impurities remains in the separator slime. A mixture of the skim milk thus purified and the cream which was separated from it is often referred to as "clarified milk."

CARE OF MILK IN THE HOME.

No matter how well milk has been handled up to the time it is delivered to the consumer, it can not be expected to keep well if it is carelessly treated thereafter. It should be poured into pitcher, pan, or other vessel—freshly scalded to remove any bacteria or mold spores—and kept in a cool, clean place free from dirt, flies, etc. New milk should never be mixed with old unless it is to be used at once, as the bacteria in the old milk will of course be added also and the mixed milk will not keep as well as the fresh milk alone. Bacteria are thickest where there is dirt and decay, and milk should therefore be stored only in clean, sweet places. It is safer to keep it covered, to exclude not only dirt and bacteria but also the flavors and odors which it so easily absorbs. If kept at a temperature of 50° F. or less, good milk should remain sweet for twelve hours, at least, after it reaches the consumer, and ordinarily for twenty-four hours or more. Sometimes in very hot weather housekeepers complain that in spite of all precautions it sours quickly, even in the ice box. This is often due to the fact that the air of the ice box, although it seems cold in contrast with the heat outside, is really not cold enough to check the growth of the bacteria; if a thermometer placed inside registers more than 50° F. the fault is almost surely in the temperature of the ice box and not in the milk.

In large cities, where most of the milk comes by morning trains from a considerable distance, it is often impossible to deliver fresh morning's milk in time for breakfast, and that milked the morning before must be given to patrons who insist on an early delivery. They would get their milk from twelve to eighteen hours fresher if they would take it in the afternoon instead.

DIGESTIBILITY OF MILK.

The amount of nourishment which any kind of food furnishes to the body depends, in the first place, on the food ingredients, the protein, fats, and carbohydrates and mineral matters which it contains, and in this respect milk is a well-balanced, nutritious food. But there is another consideration which is brought out by the much-quoted phrase, "We live not upon what we eat but upon what we digest." The nutritive value of food depends not only upon the materials it contains but also upon the amounts of those nutrients which

the body can actually utilize—upon its digestibility. As commonly used, the word digestibility refers mainly to the ease and comfort of digestion. This is an important consideration, but does not tell the whole story. As here used the words digestible and digestibility refer to the amount or proportions of the nutritive ingredients of a food material which may by the average healthy digestive organs be made available for the uses of the body. Whether milk is to be classed as a digestible or indigestible food will therefore depend upon the proportions of protein, fats, carbohydrates, and mineral matters which the digestive organs of the average normal person are found to transform into material available for the use of the body.

PROCESS OF DIGESTION.

No one element of the various digestive juices which act upon the food as it passes through the alimentary canal acts upon all classes of nutrients. All are digested separately, though sometimes simultaneously. Since milk contains considerable quantities of each class of nutrients, its digestion will be better understood if we follow the changes in each nutrient separately.

The protein compounds of milk are usually considered to give the most trouble in its digestion, and this is mainly due to the casein. Milk is commonly classed as a liquid food, but this is true only outside of the body; as soon as it reaches the stomach the rennin of the gastric juice precipitates the casein into a curd from which the other ingredients are separated, much as the whey separates from the curd in cheese making. Sometimes the curd tends to become tough and leathery and consequently difficult for the digestive juices to work upon. This is especially marked when for any reason there is considerable calcium phosphate present, and may be partially prevented by adding limewater to the milk. The acid and the pepsin of the gastric juice together work upon the curd and render a small part of it more soluble, but the bulk of the casein is digested in the small intestine by the trypsin of the pancreatic juice. Experiments[a] have shown that casein which has not been curdled by rennin is more completely digested by trypsin than the curdled. Apparently, then, the formation of the curd, especially when tough and leathery, means extra work for the digestive organs.

The albumin of the milk is for the most part easily digested by either the pepsin or the trypsin.

The digestion of fats depends mainly upon getting the globules into such fine size that they may be easily passed through the walls of the intestines. Separating the fat into such tiny globules is called

[a] Arch. Physiol. [Pflüger] (1902), p. 605.

emulsification. Another change, saponification, also helps in the absorption of fat. The alkaline pancreatic juice unites with the fatty acids of the fat to form a soap, while the glycerin is set free, much as in ordinary soap making. Both the soap and the glycerin are more easily absorbed than the original fat. The fat globules of milk are smaller than those from most other foods and are more easily emulsified; for this reason milk fat is commonly thought to be the most easily and thoroughly digested of the fats in the ordinary diet. As has been said, the size of the globules varies in milk from different animals. There is a theory that the fat of milk containing the larger globules—that is, milk on which cream rises freely (see p. 13)—is less easily digestible than that in which smaller globules remain longer in suspension.

Ordinarily the digestion of carbohydrates is begun by the saliva in the mouth, and ceases in the stomach after the food is swallowed, owing to the acid reaction of the gastric juice. The results of recent investigations make it seem certain that usually the digestion of carbohydrates continues in the stomach for a much longer period than was formerly supposed. Milk is so quickly swallowed that the saliva would have little chance to act upon the milk sugar in the mouth. Just how far this digestion would continue in the stomach before being checked by the gastric juice it is impossible to say, but there is every reason to suppose that under usual and normal conditions the bulk of the milk sugar is digested by one of the ferments of the pancreatic juice after it passes from the stomach into the intestines. Recent French studies[a] indicate that the major portion of milk and milk products leave the stomach within an hour and a half. It is commonly supposed that the lactic acid of sour milk is changed to simpler bodies in the digestive tract and assimilated, and its presence may even be beneficial in checking the growth of the putrefactive bacteria that cause intestinal disorders. (See p. 41.)

PROPORTION OF NUTRIENTS DIGESTED.

In connection with the nutrition investigations of the Office of Experiment Stations many experiments have been made to determine how thoroughly the protein, fats, and carbohydrates of milk are digested and assimilated, and much similar work has been reported by other investigators. The results obtained vary within rather wide limits, owing either to individual peculiarities of the subject or to conditions under which the milk was taken.

In persons who digest milk well the average coefficients of digestibility may run as high as 98 per cent for protein, 99 per cent for fat, and 99 per cent for carbohydrates. The average values for animal

[a] Rev. Gén. Lait., 6 (1907), p. 441.

food are 97 per cent protein, 95 per cent fat, and 98 per cent carbohydrates. In general it seems fair to say that milk is on an average as well or even more thoroughly digested than other animal foods. When milk is the only food eaten by healthy adults considerably less of the nutrients supplied are assimilated than is the case when it forms a part of a mixed diet, doubtless owing to the fact that the casein is apt to coagulate in the stomach into large lumps which resist the action of the digestive juices. It has been shown by experiments that when finer coagulation is secured the thoroughness of the digestion is increased. Taking other food with the milk hinders the formation of the lumps of casein in the stomach and so increases the thoroughness of digestion of milk. Of course, very young children digest mothers' milk alone better than any other food, but this is because of the peculiarities of their digestive organs, to which such milk is thoroughly adapted by nature, both in composition and in physical properties. If other milk is substituted for mother's milk it must be modified to secure best results. For adults in poor health milk is very commonly a most important food, and many individuals whose digestive organs are not in good condition can derive more benefit from a milk diet than from any other single food.

RELATIVE VALUE OF COOKED AND RAW MILK.

As was stated in an earlier section (p. 16), the heat of cooking produces certain chemical changes which alter the flavor and appearance of milk. In how far these changes affect its digestibility is a point on which authorities differ greatly, for although many experiments have been made to determine the facts of the case, the results are very conflicting. The principal changes, apart from the destruction of more or less of the bacteria, are as follows: Part of the protein is coagulated, it is believed, and the protein undergoes cleavage to some extent—that is, the molecule is split up into simpler forms, one of which is a volatile sulphur compound which gives freshly boiled milk its peculiar odor. If the milk is cooked in an open vessel the formation of more or less of a film or "skin" accompanies the other changes, though it is interesting to note that the formation of this skin and some of the disagreeable features which accompany it may be more or less prevented by stirring the milk while it is heating. The character of the fat globules appears to be somewhat altered by cooking, although the nature of the changes is not yet thoroughly understood; some of the other compounds which occur in small quantities also undergo cleavage and give place to new ones. The carbohydrates undergo practically no change unless the heat is continued long enough to caramelize some of the milk sugar. The longer or harder the cooking, the more noticeable are the changes.

The skin formed by heating has been commonly said to consist largely of coagulated albumin, but later investigators having found casein and lime salts in it have suggested that the heat, possibly by driving off carbon dioxid, liberates casein from lime salts, by which it is supposed to be held in solution, which then rises to the surface and is more or less dried by rapid surface evaporation. If the skin is removed it will form again, and apparently will continue to do so indefinitely. That the amount of material which may be thus removed is not great is indicated by tests [a] in which the skin from 100 cubic centimeters of milk boiled for a quarter of an hour did not contain more than 0.27 gram of protein.

The question has been studied more recently by Jamison and Hertz,[b] whose experiments showed that the formation of skin or film on milk is not a peculiar property of lactalbumin or of casein, since a similar film may be produced by warming any protein solution which contains emulsified fat. Drying was found to be an essential condition for such skin formation. The character of the films formed on milk and other protein solutions was studied, and the conclusion drawn that the film is probably composed of dried protein with fat entangled in it.

This coagulation of the protein compounds roughly resembles the hardening of the white of eggs in boiling, which is commonly said to render the egg albumin less easy of digestion. Doubtless for this reason it has been supposed that boiled milk is less easily digested than raw milk. Boiled milk coagulates less rapidly than raw milk, but under the influence of rennin the casein of the former forms about as tough a curd as that of the latter. In some processes of cheese making milk is heated before it is curdled.

It may be that cooked milk fat is less easily emulsified than raw, but not enough is known to say definitely, and the difference, if it exists, is probably slight.

Many physicians consider that infants fed for a long time on boiled or sterilized milk show a greater tendency to scurvy, rickets, and other diseases of malnutrition than when raw or pasteurized milk is used. No satisfactory explanation for this has yet been given, but there seems some reason for believing that it has to do with changes induced in the character of the calcium salts present.

Probably much of the difference of opinion regarding the value of boiled milk is due to individual peculiarities. Some healthy persons who can not eat raw milk with comfort have no trouble with it boiled, while others whom the taste of boiled milk sickens are very fond of it raw. Foods whose taste offends the palate do not stimu-

[a] Arch. Hyg., 28 (1897), p. 43.

[b] Jour. Physiol. [London], 27 (1901–2), p. 26.

late the flow of digestive juices as do pleasant ones, and so it doubtless would be wisest for the ordinary healthy person to consult his taste in choosing between the raw and cooked milk. As for infant feeding, when artificial feeding is necessary, probably the majority of physicians recommend raw or pasteurized milk unless the weather is very hot, or the quality of the milk very suspicious, or unless it is necessary to keep the milk a long time, as in traveling. It goes without saying that in infant feeding the use of cow's milk should always presuppose a product as free as possible from bacterial contamination.

MILK FOR INFANTS—MODIFIED MILK—HOMOGENIZED MILK.

It is universally admitted that the best food for infants is milk from strong, healthy women. When this is not obtainable the more nearly the substitute resembles it the better. The milk of the ass and the mare are in many important respects more like human milk than is that of the cow, and their milk used frequently to be given to babies. Goat's milk, too, is highly thought of under ordinary circumstances. At present, however, cow's milk is the most common substitute, and when necessary this is artificially modified to make it resemble human milk more closely.

A glance at the table on page 8 shows that while cow's milk contains about the same proportion of total solids and fat as woman's milk it carries more protein and less milk sugar. Besides this it has larger fat globules and there is more casein in proportion to the albumin and the casein is said to form a tougher curd than that of human milk. The deficiency in milk sugar in the cow's milk can easily be made good by adding either milk sugar itself or some other digestible carbohydrate, such as rice flour or arrowroot. The casein may be made more easy of digestion by the addition of limewater, or may be artificially predigested by peptonizing. But nothing can exactly reproduce the protein of human milk, and for this reason, perhaps more than for any other, cow's milk, no matter how skillfully modified, is never quite so satisfactory as human milk for infants.

Fortunately, most healthy babies thrive on good cow's milk or cow's milk simply modified. It is the sickly who require special preparations, and their needs vary so greatly that only the physician acquainted with the case, and not always he, can say what change is necessary.

Recognizing the important bearing of the size of the globules of the milk fat upon digestion, so-called homogenized milk is now prepared, though it is not so well known or so generally used as modified milk. In such milk the fat globules are broken down by mechanical means into very fine particles which show no marked

tendency to rise to the surface as do the fat globules of ordinary size. This change in the fat globules is usually accomplished by forcing the milk through capillary tubes and against a resisting surface. The force of impact causes the breaking up of the globules and thus makes a more perfect emulsion of the milk.

SPECIAL INFANT FOODS.

There are numerous patent infant and invalid foods on the market, some of which contain cow's milk as a basis combined with varying amounts of carbohydrates or other constituents, and others which seem to be made of farinaceous materials without milk. In some cases the carbohydrates have apparently been malted before being combined with milk or else malt extract is added during the process of manufacture.

The percentage composition of the two types of infant foods is shown in the table on page 9. The chart on page **37** shows in graphic form how commercial infant food, such as is sold in dry form, in bottles, or in cans, and is made of milk and starch, compares with some other milk products. It is also interesting to compare this product with the data showing the composition of whole milk, skim milk, etc., included in Chart II, p. 30.

Experience has shown that these special milk foods (when they really contain the nutrients of milk) are useful and valuable for infants where it is necessary to resort to some method of artificial feeding, but every one recognizes that where possible mother's milk is the best food for the young child. Too much credence should not be given to the extravagant claims made for some brands of infant foods. The safest course is undoubtedly to follow the advice of a competent physician in selecting the substitute for natural feeding. It is often wiser to use modified cow's milk in preference to these commercial foods, and it can be easily prepared at home under a physician's directions. There are also milk laboratories in many of our large cities and towns where modified milk of all sorts can be procured on prescription.

All babies fed on raw cow's milk are in more or less danger from the undesirable bacteria which it may contain and which cause diarrhea and other serious infant disorders. The question of pasteurizing and sterilizing milk in order to avoid this danger has already been spoken of (p. 16). When raw milk is used, great pains should be taken not only to obtain fresh, clean milk, but also in caring for it scrupulously after it is purchased. It is usually more important that the milk should be pure than that it should be rich in cream, especially as the fat in very creamy milk may be less digestible on account of the size of the fat globules.

NUTRITIVE VALUE OF MILK COMPARED WITH OTHER FOODS.

The value of milk for nourishment is not as generally understood as it should be. Many people think of it, for adults at least, as a beverage rather than a food, and do not realize that a glass of it adds as much to the nutritive value of a meal as a quarter of a loaf of bread or a good slice of beef. A quart of average milk contains the same amount of nutritive ingredients as 0.75 of a pound of beef or 6 ounces of bread. To put it in another way, about one-eighth of the whole weight of the milk, one-third of the beef, and two-thirds of the bread consist of actually nutritive ingredients. The other seven-eighths of the milk and one-third of the bread are water, while the two-thirds of the meat which is not actual nutriment is mainly water, though in part is bone. Chart I shows the average composition of milk, milk products, and some other common food materials. In this chart the percentage amount of refuse, water, protein, fat, carbohydrates, and mineral matter or ash is indicated by shaded portions corresponding to these different constituents, each full division of the lines representing constituents being equivalent to 10 per cent. The heavy black line indicates the number of calories per pound, each full division of this space corresponding to 400 calories.

As compared with the animal foods, it will be noted from this chart that milk contains more carbohydrates and has no refuse. In these two respects it resembles more nearly many of the vegetable foods, such as flour, oatmeal, and the like. The amount of mineral matter is much the same as in the other fresh substances given. There is a larger proportion of water in milk than in most other food materials except very succulent fruits and vegetables, so that a given weight contains less dry matter or nutrients than most foods.

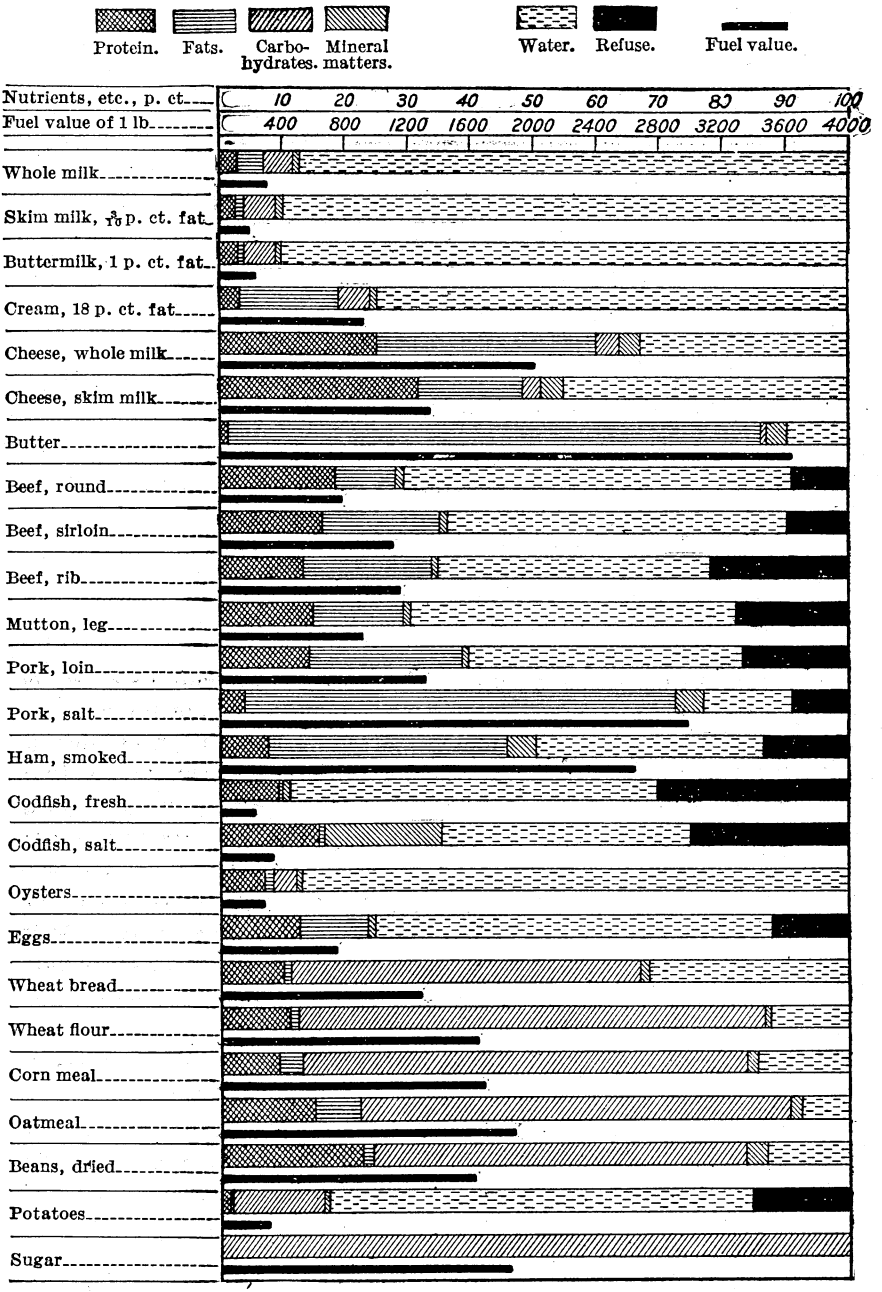
If we wish to compare the food values of the actually nutritive ingredients (the dry matter contained in the edible portion) of different food materials, the calculations may be made on the basis of 1 pound of this water-free edible portion, and the following figures show such a comparison of milk and a few other foods:

Nutrients and energy in 1 pound of the water-free edible portion of several food materials.

Food materials.	Protein.	Fat.	Carbohydrates.	Mineral matter.	Fuel value.
	Pound.	*Pound.*	*Pound.*	*Pound.*	*Calories.*
Whole milk	0.25	0.31	0.39	0.05	2,475
Skim milk (0.3 per cent fat)	.36	.03	.55	.06	1,835
Buttermilk	.33	.06	.53	.08	1,845
Cheese	.39	.52	.03	.06	2,990
Beef, round	.57	.40	.....	.03	2,750
Smoked ham	.26	.66	.....	.08	3,275
Wheat flour	.13	.01	.85	.01	1,865
Wheat bread	.15	.02	.82	.01	1,865
Potatoes	.10	.01	.85	.04	1,790
Apples	.03	.03	.92	.02	1,885

CHART I.—*Percentage composition and fuel value of milk, milk products, and some other foods.*

(The constituents are expressed in per cent, the fuel values in calories per pound.)



One of the most common statements regarding milk is that it is a "perfect food." In one sense this is true, but in another it is not. The normal milk of any mammal may be perfectly adapted to the nourishment of its offspring, but the milk of one mammal, such as the cow, is not necessarily a perfect food for the young of another species, such as the human infant; nor is any milk a perfect food for a healthy adult of any species. Though an extremely valuable food, differing from all others except possibly eggs in that it contains fairly good proportions of all the ingredients necessary for the building and repair of the body and for supplying it with energy for its activities, the ingredients are so diluted with water that it would require a large quantity (4 or 5 quarts each day) to meet the needs of the adult body, and to get the required amount of energy from milk unnecessary quantities of protein must be consumed. Furthermore, healthy digestive organs can do their work better when at least part of the food is in solid form. Even for adults, however, milk alone can support life for a considerable time, if not indefinitely, but its chief value is in combination with other foods; not as a beverage merely, but to supply in part the material needed for the body. For infants it is almost indispensable, and for invalids it is a nutritious, easily digested food, which the physician can readily control.

NUTRITIVE VALUE OF SKIM MILK.

As every one knows, skim milk is the milk which remains after the butter fat—that is, cream—has been removed. In the ordinary process of skimming the cream is allowed to rise in pans or other convenient receptacles, and the layer of cream on top is removed with a skimmer or some other convenient device. Formerly hand skimming was universal, but at the present time milk separators are in common use, which embody in their construction the physical principle that with rapidly rotating material the heavier body moves from the center to the circumference more rapidly than the lighter body. Milk separators permit of the convenient removal of any desired proportion of the butter fat, and in general remove the fat much more completely than is possible by hand skimming.

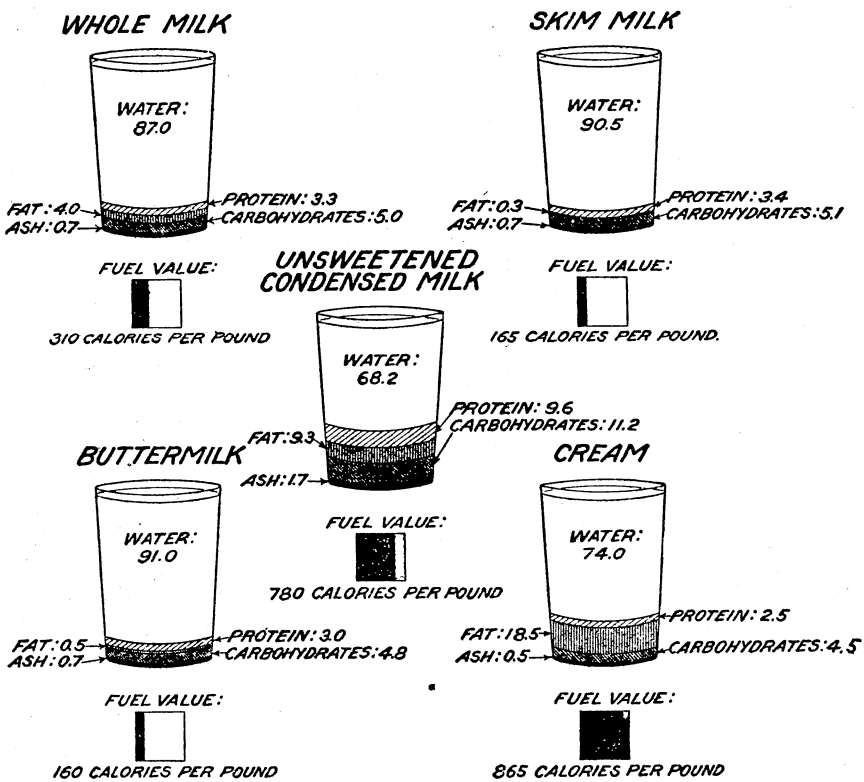
In this and Chart IV the outline figure, representing the glass of milk or some other convenient quantity, is so divided that the percentage amount of the different constituents is indicated graphically. In the case of fuel values, the rectangular figure, representing 1,000 calories or some multiple of 1,000, is so divided that the black portion indicates the number of calories per pound supplied by the food material under consideration.

When whole milk and skim milk are compared, as in the table on page 9, and the chart on page 30, it will be seen that though the latter

is deficient in fat this is not the case as regards protein, carbohydrates, and ash. This is even more evident when the two sorts of milk are compared on a dry-matter basis. Such a comparison suggests a very important topic, namely, the great nutritive value of skim milk. Even after average milk is skimmed—that is, after the bulk of the fat is removed—the solids, or nutritive ingredients, still make up nearly one-tenth of its entire weight. The amount of fat left in skim milk varies greatly with the method of creaming. Ordinary open,

CHART II.—*Percentage composition and fuel value per pound of whole milk and some milk products.*

(The constituents are expressed in per cent, the fuel values in calories per pound.)



shallow pan setting leaves anywhere from one-tenth to one-fourth of the original fat of the milk in the skim milk. Deep, cold setting removes the fat much more completely, and separator skim milk has usually less fat than that from deep, cold setting. It is not far out of the way, however, to say that a pound of skim milk contains on the average 0.034 pound protein and has a fuel value of 170 calories, or a little greater proportion of protein than the same weight of whole milk and about one-half the fuel value.

In the ordinary mixed diet a sufficient amount of fat is supplied by meat, butter, lard, etc., so that the loss of this ingredient is of relatively little importance. Protein, on the other hand, is the most costly of the food ingredients and the one most likely to be lacking in inexpensive meals, and this is the nutrient which skim milk supplies in a cheap and useful form. The value of skim milk as food is not generally appreciated. Taken by itself it is rather "thin" and, to use a common expression, "does not stay by." It is not as rich in flavor as whole milk, but when taken with bread or used in cooking, it forms a very nutritious addition to the food. A pound of lean beef (round steak, for example) contains about 0.18 pound of protein and has a fuel value of 870 calories. Two and a half quarts or 5 pounds of skim milk will furnish nearly the same amount of protein and have about the same fuel value as the pound of round steak, while it would cost hardly a quarter as much. Two quarts of skim milk have a greater nutritive value than a quart of oysters; the skim milk has 0.14 pound of protein and a fuel value of 680 calories, while the oysters contain only 0.12 pound of protein and have a fuel value of 470 calories. The nutriment in the form of oysters would cost from 30 to 50 cents, while the 2 quarts of skim milk would have a market value of from 4 to 6 cents and a value on the farm of from 2 to 4 cents.

A lunch or meal of bread and skim milk is very nutritious in proportion to its cost and convenience, as the following computation shows:

Composition and cost of a lunch or meal of bread and skim milk.

Food materials.	Amount.	Estimated cost.	Protein.	Fuel value.
	Ounces.	*Cents.*	*Pound.*	*Calories.*
Bread	8	3	0.05	604
Skim milk (1 pint)	8	2	.04	255
Total		5	.09	859

The commonly accepted standard for a man at moderately active muscular work calls for 0.28 pound of protein and a fuel value of 3,500 calories per day, so that the above lunch furnishes very nearly one-third of a day's nutriment and at a cost of but 5 cents. If whole milk were used instead of skim milk, the cost would be about 7 cents and the fuel value 1,080 calories, while the protein would remain the same in amount.

The following lunch, such as might be obtained in a restaurant or lunch room, will serve for the purpose of comparison:

Estimated cost and nutrients of a restaurant lunch.

Food materials.	Amount.	Estimated cost.	Protein.	Fuel value.
	Ounces.	*Cents.*	*Pound.*	*Calories.*
Soup	8.0	.....	0.01	75
Beef	2.0	.....	.02	275
Potatoes	2.0	.....	.....	100
Turnips	1.0	.....	.....	15
Bread	3.0	.....	.02	225
Butter	.5	.....	.....	100
Coffee:				
Milk	1.0	.....	.....	20
Sugar	.5	.....	.....	55
Total	.....	15–20	.05	865

It will thus be seen that the 15-cent lunch, containing nine different food materials, would not have any greater nutritive value than the 5-cent lunch of bread and skim milk; though it contained a few calories more of energy, it would yield only about half as much protein.

The idea that only whole milk is fit to use, which is rather erroneously held by housewives, is perhaps ascribable to the esteem in which cream is held as an ingredient of "rich food," and may lead to quite needless waste or expenditure. For growing children, who need large quantities of protein and carbohydrates, 2 quarts of skim milk would supply more of these constituents and more ash than 1 quart of whole milk, and it has already been suggested that fresh skim milk of good quality, sold under its real name and at a reasonable price, is preferable to suspicious whole milk. Many families who are in the habit of drinking whole milk and buying cream would doubtless be quite as well off if the top of the milk, say 2 or 3 inches in a quart bottle, were poured into the cream instead of the milk pitcher; the milk ought still to be far from thin and blue, and there would be a marked saving in the cost of cream. On the farm skim milk is often considered fit only for the pigs; but it really may be used in cookery, etc., as a useful and economical food, though it is only fair to say that on a farm milk is often so abundant that the fresh whole milk will naturally be selected for culinary and table purposes. The fresh whole milk seems to most persons more tempting as a beverage, perhaps, than older skim milk, though this is a matter largely of cultivation and habit; but if no one cares to drink it the skim milk can always be used in cooking, as will be discussed in a later section, a fact of more importance from the standpoint of economy in families where milk is purchased than in those where it is produced.

COST OF NUTRIENTS IN WHOLE MILK AND SKIM MILK.

Just as the nutritive value of a given food depends not simply on its chemical composition but on its proportion of digestible nutrients, so its real cheapness or dearness depends not on the price per quart or per pound, but on the amount of digestible nutrients which a given sum will purchase. Milk is economical in the sense that it contains no refuse, such as the bone and gristle of meat, the shells of eggs, and the skins and seeds of vegetables. Moreover, the proportion of its nutrients which can be digested and utilized by the body is, under ordinary circumstances, larger than that from most food materials. The thing which might make milk expensive is its diluteness—that is, the large amount of water which it contains in proportion to its solid matter.

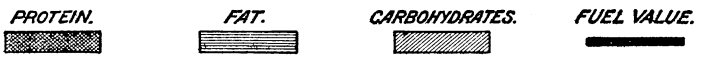
The accompanying chart will help in showing the real cheapness or dearness of milk at various prices as compared with other foods. In this chart the amount of nutrients is indicated by the shaded portions corresponding to the protein, fat, and carbohydrates, the length of each portion representing the number of pounds or fractions of a pound of the constituent which is supplied, each full division of the chart being equivalent to 1 pound. The heavy black line indicates the number of calories per pound, each full division of the chart corresponding to 2,000 calories.

The whole milk represented contains the average amounts of solid matter, regardless of price. Milk selling at 10 cents a quart ought to contain larger proportions than that selling at 5 or 6, besides having fewer bacteria; on the other hand, milk at the lower prices may occasionally contain larger proportions than the more expensive, but it is impossible to represent such variations satisfactorily. For the purposes of the present comparison the average composition will be sufficiently accurate.

Of course, in comparing milk and such material as dried beans, one must take into account the fact that the beans will absorb considerable water in cooking and that a pound of them ready to eat would not contain as much nourishment as is represented in the chart, while milk is consumed as bought. In addition, the cost of cooking must always be considered in connection with foods which are not eaten raw.

Bearing these things in mind, we see that milk at all but the highest prices assumed is a cheaper source of protein than any of the animal foods except cheese, very cheap meat, and salt fish. At usual prices skim milk furnishes protein more cheaply than any common animal food except salt fish. The protein of vegetable foods is less expensive, but, on the other hand, as prepared for the table is less thoroughly digested. Moreover, it is accompanied by such large amounts of

CHART III.—*Pecuniary economy of milk and other foods. Amount of actual nutrients obtained in different foods for 10 cents at certain assumed prices per pound.*



FOOD MATERIAL.	PRICE PER POUND	TEN CENTS WILL BUY	POUNDS OF NUTRIENTS AND CALORIES IN TEN CENTS' WORTH. 1 lb. 2000 Cal. 2 lbs. 4000 Cal. 3 lbs. 6000 Cal.
	Cts.	Lbs.	
WHOLE MILK 10 CENTS PER QT.		2.00	
WHOLE MILK 8 CENTS PER QT.		2.50	
WHOLE MILK 7 CENTS PER QT.		2.88	
WHOLE MILK 6 CENTS PER QT.		3.31	
WHOLE MILK 5 CENTS PER QT.		4.00	
SKIM MILK 3 CENTS PER QT.		6.69	
SKIM MILK 2 CENTS PER QT.		10.00	
BUTTER	25	.40	
CHEESE	16	.63	
BEEF, ROUND	14	.71	
BEEF, SIRLOIN	20	.50	
MUTTON, LEG	16	.63	
PORK, LOIN	12	.83	
PORK, SALT, FAT	12	.83	
HAM, SMOKED	18	.56	
CODFISH, FRESH, DRESSED	10	1.00	
CODFISH, SALTED	7	1.43	
OYSTERS 35 CENTS PER QUART	18	.56	
EGGS 24 CENTS PER DOZEN	16	.63	
WHEAT FLOUR	3	3.33	
CORN MEAL	2½	4.00	
OAT MEAL	4	2.50	
BEANS, WHITE, DRIED	5	2.00	
RICE	8	1.25	
POTATOES 60 CENTS PER BUSHEL	1	10.00	
SUGAR	6	1.67	

carbohydrates that to secure much vegetable protein in the diet usually means an excess of the carbohydrates. Under ordinary market conditions milk, and even skim milk, is a cheaper source of body fuel than any of the usual animal foods except cheese and salt pork, but is a dearer one than the usual vegetable foods. Here again, however, the milk furnishes the ingredients in a form more readily and thoroughly digested than the vegetable foods as ordinarily served. Milk, then, is fully as economical a source of nutrients as most animal foods, but is dearer than most vegetable foods. It has the decided advantage of having no waste, requiring no time for preparation, and being more digestible than the vegetable foods. Skim milk answers the most important purposes of milk in the ordinary mixed diet, and under usual market conditions costs at most only half as much as whole milk. Both whole and skim milk at moderate prices are therefore to be ranked among the most economical of our foods, not only when taken as beverages, but also when used in preparing other foods.

THE USE OF MILK IN COOKING.

If freely used in the preparation of other foods, milk can be made to add considerably to the food value of the meals. Many dishes are, of course, richer in flavor if whole milk is used rather than skimmed, but for the purpose of increasing the food value of the diet the main nutritive ingredient—that is, the nitrogenous material—as we have seen, is in the skim milk; if the extra fat is needed, it may be supplied in the form of butter, which is usually a more economical source than whole milk, or in the form of lard or other culinary fat.

Most persons consider that the choice between bread made with milk and that made with water depends simply upon the taste and appearance. There is, however, a difference in the food value, as will be seen from figures showing the average composition of various foods prepared with milk and of similar dishes in which it is not used. According to the figures which were taken from analyses made at the University of Minnesota,[a] bread made with skim milk is richer in total solids, protein, and fats than otherwise similar bread made with water. The differences are not very great, but they are well worth considering, especially where skim milk is a drug in the market. The importance of skim milk in bread making has also been demonstrated experimentally at the Maine Experiment Station.

Milk soups furnish an excellent means of increasing the food value of a meal or of using up superfluous milk. Sometimes the milk is mixed with "stock" made from meat, and sometimes, as in vegetable purées, it forms the basis to which the pulp of some vegetable, such as beans, peas, potatoes, corn, or celery, is added to give flavor and

[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 67.

"body." Oyster stew made with milk owes its food value more to the milk than to the oysters.

Milk or "white" and "cream" sauces are also very useful, not only for the nutritive material they supply but also as a help in using up "left overs." Bits of meat can often be made very attractive by serving them on toast minced and "creamed," and many warmed-over vegetables are improved by the addition of milk or white sauce, while the same sauce also helps in giving variety in winter when not many kinds of vegetables are to be had. There is almost no end to the puddings and desserts in which considerable milk is used. Blanc mange is practically flavored milk, jellied with starch, Irish moss, or some similar material, and the simplest kinds of ice cream are milk and cream mixtures flavored and frozen. Junket is simply milk curd separated by rennet, as in cheese making, and eaten before the bacteria which give the cheese its flavor develop. Then there are all the puddings made of some form of cereal and milk and flavored in some way, as bread puddings, cornstarch, rice, and tapioca puddings, and the countless forms of custard of which milk and eggs make the basis. Almost all of these, if carefully made, are nutritious, easily digested, and economical. For children and persons of weak digestion the simpler ones like blanc mange, cornstarch, and rice puddings are almost indispensable.

MILK PRODUCTS.

BUTTER AND CHEESE.

These are by far the most important products of the dairy industry, but so much has been written of them in other publications of this Department that they need only be mentioned briefly here.

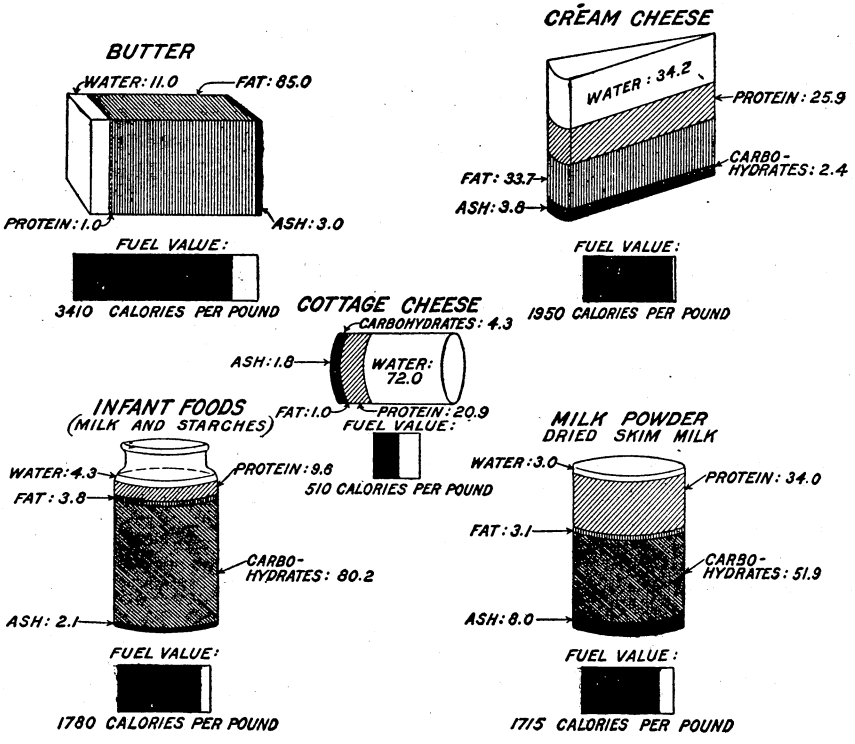
Chart IV shows in graphic form the composition of butter, cheese, and other milk products. The data are given in tabular form for these and other foods on page 9.

Butter, which is practically separated milk fat, is one of the most important sources of fat in our diet and certainly the most palatable and one of the most digestible. Its flavor depends upon such factors as volatile fats, cleanliness, the action of bacteria, and the amount of salt added. The price varies greatly, even during the same season, and is influenced by flavor, color, texture, etc. These factors affect quality rather than composition, and so far as is known have little effect on nutritive value or digestibility. As has been stated already, it is usually a cheaper source of pure fat than whole milk. The butter on sale in the United States is usually salted, partly because of the general preference for the salt flavor and partly because of improved keeping qualities. It is noticeable that butter is

now less heavily salted than was the case before cold storage and other such conveniences became common. In Europe sweet or unsalted butter is very popular, and its popularity is growing in the United States. Such butter has a mild, creamy flavor, which very many relish. As it does not keep well it must be used soon after it is made, and ranks as a delicacy. Many persons make sweet butter at home as needed, using for the purpose an egg beater or one of the devices similar in principle which are on the market for this purpose.

CHART IV.—*Percentage composition and fuel value per pound of butter, cheese, and other milk products.*

(The constituents are expressed in per cent, the fuel values in calories per pound.)



A peculiar form of butter, called "ghee," is commonly used in India and central Asia. The water is boiled out from freshly made butter and the resulting product is kept for general use, especially in cooking. In the cold, high regions of Tibet it is used in large quantities, lumps of it being put even into tea. This product is very similar to the rendered butter which is used by orthodox Jews in kosher cookery. Rendered butter is also a common culinary fat in Egypt and some other countries.

Cheese consists of the casein of the milk and more or less of the fat and mineral matters which are precipitated along with it when rennet is added to milk. There are countless varieties made not only from cow's milk but also from that of goats, ewes, and other animals. The flavor is due chiefly to the action of ferments, of bacteria, or of molds. The changes which these agents induce are now well understood, and the manufacture of cheese of different types is an important industry in which the expert cheese maker now utilizes them according to scientific methods to bring about the desired results with almost unvarying certainty. The literature of food and nutrition contains little definite information regarding the digestibility of cheese, but there is a general opinion that this food, particularly the very strong varieties, is less easily digested than most milk products. As regards thoroughness of digestion, a very large number of digestion experiments carried on by the Office of Experiment Stations in cooperation with the Bureau of Animal Industry of the Department of Agriculture have shown that, when consumed even in relatively large amounts, cheese is very thoroughly assimilated. Furthermore, it caused no physiological disturbances in the large number of tests in which it was used. Cheese, containing, as it does, almost all of the protein and fat of the milk from which it is made and having a comparatively low water content, is a very nutritious food, and the cheaper kinds may well be used more abundantly than is commonly the case in this country as a part of the regular diet and not simply as a condiment at the end of the hearty meal. The cost of cheese varies greatly with the kind, but the higher prices are usually paid for distinctive flavors or texture rather than for food values.

JUNKET.

A favorite dish for invalid dietetics and for more general use is prepared by adding rennet to milk and allowing it to stand undisturbed until it thickens or coagulates—that is, until the casein is precipitated. If the process is carefully carried out a thick, custard-like product results. If, however, it is stirred the casein readily breaks up and separates from the whey. There are a number of preparations of rennet on the market designed especially for making junket, all of which seem to give satisfactory results.

COTTAGE CHEESE.

Cottage cheese as commonly made at home from sour milk with or without the cream is a nutritious and palatable food, as may be seen from figures for its composition in the table on page 9, and the data given in Chart IV, page 37. Under ordinary conditions it is very inexpensive. There are several sorts of this cheese on the market

which are made in large quantities as regular commercial products and sold under such names as Neufchatel, or, less commonly, cream cheese. In many city markets the homemade product may also be purchased. Cottage cheese is used as a palatable addition to the diet, alone or seasoned in various ways, and is also used in the preparation of a number of dishes.

CREAM.

Cream is made up principally of water and the fat of milk, but contains also a little protein, carbohydrates, and mineral matters. When served with cereals, fruit, etc., it not only improves the flavor, but adds to the nutritive value of the dish. When added to the custards, cakes, soups, and other food it materially increases the fat content and makes the dish "richer," as does cream, either plain or whipped, served with a dessert dish or other food.

Judging by available data, cream in large quantities is less easily digested than the same amount of whole milk, because it contains so much fat; but, on the other hand, it is more thoroughly digested than most other forms of fat, and is often ordered by physicians when the amount of this ingredient in the diet is to be increased. At usual prices it is so expensive that it must be considered a luxury to most people who purchase their milk and cream.

When cream is beaten or whipped the fine bubbles formed do not break readily, so that it may be whipped until it is stiff, almost like egg white. If the "whipping" is too long continued the fat globules separate, and butter results. If cream is too thin it does not whip well, and the same may be said of very thick cream. Several explanations of this property of "whipping" have been offered, but it seems fair to say that no entirely satisfactory explanation has been given. That the property may be dependent upon the calcium content of the milk is suggested by the fact that cream to which a small amount of a solution of lime in sugar and water has been added may be readily whipped. This question has been carefully studied at the Wisconsin Station, and it was found that if a small portion of such a lime solution was added to pasteurized cream which ordinarily does not whip readily, or to thin cream, satisfactory results could be obtained.

A cream product known as "Devonshire clotted cream," or simply as "clotted cream," and very popular in Great Britain and, to a less extent, elsewhere, is made by allowing pans of milk to stand undisturbed in a cool place until cream rises and then scalding, care being taken not to disturb the cream on top of the milk. When this is properly done and the pans allowed to cool, the cream may be taken off in a thick, clotted condition, and is ready for use. It has a peculiar, nutty flavor, which most persons relish.

BUTTERMILK.

Besides skim milk, there is another important by-product resulting from the manufacture of butter, namely, buttermilk. In butter making the fat globules are brought together by churning and removed, leaving a thin liquid. This buttermilk is very like skim milk in composition, but it has usually a mild acid taste, because the cream is generally allowed to sour before churning. Buttermilk is often used as a beverage, and has much the same food value as skim milk. An ordinary glass would contain about as much nourishment as 2 ounces of bread, a good-sized potato, or a half pint of oysters. To many persons buttermilk is as palatable, or even more palatable, than whole or skim milk, but others find the sour taste very unpleasant. This sour taste is due mainly to lactic acid, and does not make the buttermilk less digestible. On the contrary, its casein forms a more flaky curd than that of ordinary milk. Buttermilk is frequently fed to babies, especially in Holland, and is sometimes prescribed when the protein of ordinary milk proves indigestible. Its general use is increasing in this country. Buttermilk ice cream is considered a delicacy in some sections, especially for invalids.

Condensed buttermilk is manufactured to some extent, but seems to be best known in Europe, and is certainly not common even there.

WHEY.

Just as buttermilk represents the residue of milk from butter making, so whey represents what is left from cheese making, and consists mainly of water, milk sugar, and mineral matters. It is less nutritious than skim milk and buttermilk, but is occasionally useful as a mild laxative drink for invalids. In the "whey cures" for dyspeptics, of which so much was heard some years ago, whey was usually combined with a simple vegetable diet and the beneficial results were probably due as much to the simple, out-of-door life, which made part of the treatment, as to the whey itself.

Whey may be made at home by cooking sweet milk with some acid material, such as vinegar, lemon juice, sour wine, or cream of tartar, or even with sour milk. Such whey differs but little in composition from regular cheese whey. Fresh curds and whey is an old-fashioned dish still used to some extent, though less common than it was when cheese making was regularly carried on as a home industry.

SOUR MILK OR CLABBER.

Sour milk or clabber is a common article of diet in many parts of the United States and is wholesome, and to those who care for it very refreshing and palatable. It is certainly nutritious, since when

made from whole milk it contains all the nutritive ingredients originally present, and when only skim milk is used it contains the casein and other constituents except the fat. Usually no special methods are followed to prepare sour milk or clabber for table use, though most housewives recognize the fact that if the souring takes place too slowly the clabber may have a bitter or unpleasant flavor. This is, of course, due to the development of undesirable bacteria along with those which cause the souring of the milk. Sour milk is much used in cookery, and adds materially to the nutritive value of the dish of which it forms a part. Before baking powders became so common sour milk and baking soda were very commonly used to leaven doughs and batters of various sorts. Some cooks maintain that they can secure the best results by using only the whey of sour milk, but this naturally gives a less nutritious dish and therefore is not so desirable.

KEPHIR, KOUMISS, AND OTHER FERMENTED MILK PRODUCTS.

Since earliest times fermented-milk products have been used as beverages and articles of diet in Central Asia, Turkey, and other countries. These products are prepared by allowing special ferments or yeasts to develop in milk, and like all fermented beverages owe their sparkling or effervescent qualities to the carbon dioxid produced by the action of organisms. The flavor differs with the process of manufacture. These fermented-milk beverages have proved very satisfactory in invalid dietetics and are now well known and commonly used. Fermented-milk beverages may be made at home, but are perhaps more commonly commercial products in the United States. In this country cow's milk is almost universally used to make these beverages, but other milk, for instance, mare's milk, is more common in Central Asia and other regions.

A carbonated milk, which is made by charging milk with carbon dioxid, is sometimes found on sale, but, of course, lacks the special qualities which all the fermented products contain.

Some of these fermented-milk products contain lactic acid forming bacteria in great abundance, and their extensive use has been much discussed recently, owing to the prominence which has been given to the theory that very many diseases, particularly those incident to old age, are the results of the development of putrefactive bacteria in the intestine and the possibilities of hindering the growth of such organisms by the presence of lactic acid. The most recent observations, however, make it doubtful whether it is as beneficial as has been claimed by some enthusiasts.

SUMMARY.

Some idea of the importance of milk as human food may be gained from the fact that about one-sixth of the total food of the average family is furnished by it and its products. Milk from various mammals is used in various parts of the world, but with us that of the cow so far surpasses all other kinds in importance that unless otherwise specified the word "milk" is taken to refer to cow's milk only. Few staple foods vary so much in composition, but, on the average, good, unadulterated milk should contain about 87 per cent water and 13 per cent solids. About one-fourth of these solids are furnished by the protein compounds, casein, and albumin, the casein being five or six times more abundant than the albumin. Fats (butter fat) form one-third of the total solids. Butter fat occurs in globules throughout the milk, and it is upon the size and number of them that the creaminess of milk depends. The larger the globules the more easily and completely will they rise as cream to the surface of the milk. Carbohydrates make up 38 per cent of the solids, by far the most important of them being lactose, or milk sugar. The remaining 5 per cent of solids consists of mineral matters, the bulk of which are phosphates and chlorids of soda, potash, and lime.

Besides these chemical constituents, milk almost inevitably contains bacteria of many kinds and in varying numbers. They cause the souring of milk and the ripening of cream and cheese, and produce many other changes in the appearance and flavor. The number present in freshly-drawn milk varies enormously with the conditions of milking, and, as they are greatly increased with dirty and careless handling, cleanliness in all matters pertaining to the milking and marketing of milk and keeping it in the home can not be too strongly insisted on. Disease germs, notably those of typhoid, diphtheria, scarlet fever, and tuberculosis, may also be carried in milk, so that the purity of the milk supply is of vital importance to every family and community.

Although some of the bacteria in milk are essential in the manufacture of butter and cheese, they are as a class a source of danger to the ordinary consumer. Without them milk would stay sweet indefinitely, and the problem of keeping milk is simply one of checking their growth. The less there are in the fresh milk, the slighter the danger, hence the superior keeping qualities of milk from a clean, well-ordered dairy. They are comparatively inactive at a temperature below 50° F., and therefore milk should be kept in a cool place. Freezing does not kill bacteria and produces undesirable changes in the milk. Extreme heat does kill them, but also produces other undesirable changes. Nevertheless, heat is employed to preserve milk in the two common methods of pasteurization and sterilization. In

the former the aim is to apply heat in such a way as to kill the most bacteria without producing the undesirable changes; in the latter, to apply enough heat to kill all the bacteria, but with the least possible undesirable change. Bacteria require moisture as well as heat for their growth, therefore by extracting the water, as in condensed milk, milk powders, etc., milk may be preserved indefinitely. Another way of keeping it is by the use of chemicals to kill the bacteria, but as such chemicals may be injurious to human beings as well, such practices are not usually to be recommended.

What is commonly known as the richness of milk depends upon the amount of fat. This varies so greatly in milk from different animals and is so easily reduced by a fraudulent dealer that many efforts have been made to regulate the price of milk according to its fat content. Milk graded according to government standards is sold in some cities, especially in Europe. Certified milk—that is, milk in sealed jars from establishments regularly inspected—is more commonly known in this country, and rightly commands a higher price than that from uncertain sources. Of course, cleanliness and care are as important in keeping milk in the home as in the dairy and market, and each housekeeper should see to it that all receptacles in which it is kept are thoroughly scalded each time they are used; if this is neglected, bacteria from the old milk will contaminate the fresh.

Compared with other food materials, milk furnishes the nutritive ingredients in forms in which they may be easily and thoroughly digested by the normal, healthy person, and often by those of impaired health. Boiling is believed by many to make the protein slightly less digestible, but as yet knowledge on this point is incomplete. The digestibility of the fat seems to depend upon the size of the globules, the smaller ones being more easily absorbed. This explains why rich, "creamy" milk, such as that given by the Channel breeds, sometimes causes digestive trouble in children.

Mother's milk is best adapted by nature to the nourishment of infants, and differs from cow's milk mainly in the character of its protein, in the smaller size of its fat globules, and in its greater amount of milk sugar. When necessary, cow's milk may be artificially modified to approach it more nearly in composition, but the results are not always satisfactory, especially as regards the protein.

Milk contains too much water to be a perfect food for adults; nevertheless, its solids furnish all the necessary ingredients and in good proportions. A large glass of it yields as much nourishment as a slice of roast beef.

Unless exceptionally high prices are paid for it, milk is fully as economical a source of nutrients as other animal foods, but dearer

than most staple vegetable products. It should be borne in mind, however, that it requires no preparation, has no waste, and is more thoroughly digested than most vegetable foods. As a source of protein, the most expensive of the nutritive ingredients, it is especially economical. Skim milk, which is whole milk minus part of its fat, and which costs only half as much as whole milk, furnishes protein about four times as cheaply as beef, and since fat is usually abundant in the ordinary mixed diet might most advantageously be used in the place of whole milk in dietaries where cost must be carefully considered. The freer use of skim milk in cooking is also to be recommended. Of course, foods prepared with either skim or whole milk are by so much the more nutritious than those prepared with water.

Butter and cheese are the most important milk products. Butter is one of the chief sources of fat in the ordinary diet and furnishes it in a very palatable and easily digested form. Cheese consists of the casein of milk plus more or less of the fat and mineral matters. The flavor and texture of the many varieties are due mainly to the peculiar bacteria and ferments which the various methods of manufacture develop. The less expensive varieties make one of the cheapest sources of protein, and might well be more freely used as part of the regular diet. Digestion experiments indicate that the common and milder varieties are more easily and thoroughly assimilated than is sometimes supposed. The other milk products—junket, whey, buttermilk, clabber, and the fermented forms, such as kephir and koumiss—are all nutritious foods and are often of especial value in invalid diet. In short, milk and its products are fully entitled to their prominent place in our food list as comparatively inexpensive, easily digested sources of all the necessary ingredients of our diet.

FARMERS' BULLETINS.

Bulletins in this list will be sent free, so long as the supply lasts, to any resident of the United States, on application to his **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington, D. C. Because of the limited supply, applicants are urged to select only a few numbers, choosing those which are of special interest to them. Residents of foreign countries should apply to the Superintendent of Documents, Government Printing Office, Washington, D. C., who has these bulletins for sale. Price 5 cents each to Canada, Cuba, and Mexico; 6 cents to other foreign countries. The bulletins entitled "Experiment Station Work" give briefly the results of experiments performed by the State experiment stations.

22. The Feeding of Farm Animals.
27. Flax for Seed and Fiber.
28. Weeds: And How to Kill Them.
30. Grape Diseases on the Pacific Coast.
32. Silos and Silage.
34. Meats: Composition and Cooking.
35. Potato Culture.
36. Cotton Seed and Its Products.
42. Facts About Milk.
44. Commercial Fertilizers.
48. The Manuring of Cotton.
49. Sheep Feeding.
51. Standard Varieties of Chickens.
52. The Sugar Beet.
54. Some Common Birds.
55. The Dairy Herd.
56. Experiment Station Work—I.
60. Methods of Curing Tobacco.
61. Asparagus Culture.
62. Marketing Farm Produce.
63. Care of Milk on the Farm.
64. Ducks and Geese.
65. Experiment Station Work—II.
69. Experiment Station Work—III.
73. Experiment Station Work—IV.
77. The Liming of Soils.
78. Experiment Station Work—V.
79. Experiment Station Work—VI.
81. Corn Culture in the South.
82. The Culture of Tobacco.
83. Tobacco Soils.
84. Experiment Station Work—VII.
85. Fish as Food.
86. Thirty Poisonous Plants.
87. Experiment Station Work—VIII.
88. Alkali Lands.
91. Potato Diseases and Treatment.
92. Experiment Station Work—IX.
93. Sugar as Food.
96. Raising Sheep for Mutton.
97. Experiment Station Work—X.
99. Insect Enemies of Shade Trees.
100. Hog Raising in the South.
101. Millets.
103. Experiment Station Work—XI.
104. Notes on Frost.
105. Experiment Station Work—XII.
106. Breeds of Dairy Cattle.
110. Rice Culture in the United States.
113. The Apple and How to Grow It.
114. Experiment Station Work—XIV.
118. Grape Growing in the South.
119. Experiment Station Work—XV.
120. Insects Affecting Tobacco.
121. Beans, Peas, and Other Legumes as Food.
122. Experiment Station Work—XVI.
126. Practical Suggestions for Farm Buildings.
127. Important Insecticides.
128. Eggs and Their Uses as Food.
131. Household Tests for Detection of Oleomargarine and Renovated Butter.
133. Experiment Station Work—XVIII.
134. Tree Planting on Rural School Grounds.
135. Sorghum Sirup Manufacture.
137. The Angora Goat.
138. Irrigation in Field and Garden.
139. Emmer: A Grain for the Semiarid Regions.
140. Pineapple Growing.
142. Principles of Nutrition and Nutritive Value of Food.
144. Experiment Station Work—XIX.
145. Carbon Bisulphid as an Insecticide.
149. Experiment Station Work—XX.
150. Clearing New Land.
152. Scabies of Cattle.
154. The Home Fruit Garden: Preparation and Care.
155. How Insects Affect Health in Rural Districts.
156. The Home Vineyard.
157. The Propagation of Plants.
158. How to Build Small Irrigation Ditches.
162. Experiment Station Work—XXI.
164. Rape as a Forage Crop.
166. Cheese Making on the Farm.
167. Cassava.
169. Experiment Station Work—XXII.
170. Principles of Horse Feeding.
172. Scale Insects and Mites on Citrus Trees.
173. Primer of Forestry. Part I: The Forest.
174. Broom Corn.
175. Home Manufacture and Use of Unfermented Grape Juice.
176. Cranberry Culture.
177. Squab Raising.
178. Insects Injurious in Cranberry Culture.
179. Horseshoeing.
181. Pruning.
182. Poultry as Food.
183. Meat on the Farm: Butchering, Curing, and Keeping.
185. Beautifying the Home Grounds.
186. Experiment Station Work—XXIII.
187. Drainage of Farm Lands.
188. Weeds Used in Medicine.
190. Experiment Station Work—XXIV.
192. Barnyard Manure.
193. Experiment Station Work—XXV.
194. Alfalfa Seed.
195. Annual Flowering Plants.
196. Usefulness of the American Toad.
197. Importation of Game Birds and Eggs for Propagation.
198. Strawberries.
200. Turkeys.
201. Cream Separator on Western Farms.
202. Experiment Station Work—XXVI.
203. Canned Fruits, Preserves, and Jellies.
204. The Cultivation of Mushrooms.
205. Pig Management.
206. Milk Fever and Its Treatment.
209. Controlling the Boll Weevil in Cotton Seed and at Ginneries.
210. Experiment Station Work—XXVII.
213. Raspberries.
218. The School Garden.
219. Lessons from the Grain Rust Epidemic of 1904.
220. Tomatoes.
221. Fungous Diseases of the Cranberry.
222. Experiment Station Work—XXVIII.
223. Miscellaneous Cotton Insects in Texas.
224. Canadian Field Peas.
225. Experiment Station Work—XXIX.
227. Experiment Station Work—XXX.
228. Forest Planting and Farm Management.
229. The Production of Good Seed Corn.
231. Spraying for Cucumber and Melon Diseases.
232. Okra: Its Culture and Uses.
233. Experiment Station Work—XXXI.
234. The Guinea Fowl.
235. Preparation of Cement Concrete.
236. Incubation and Incubators.
237. Experiment Station Work—XXXII.
238. Citrus Fruit Growing in the Gulf States.
239. The Corrosion of Fence Wire.
241. Butter Making on the Farm.
242. An Example of Model Farming.
243. Fungicides and Their Use in Preventing Diseases of Fruits.
244. Experiment Station Work—XXXIII.
245. Renovation of Worn-out Soils.

246. Saccharine Sorghums for Forage.
248. The Lawn.
249. Cereal Breakfast Foods.
250. The Prevention of Stinking Smut of Wheat and Loose Smut of Oats.
251. Experiment Station Work—XXXIV.
252. Maple Sugar and Sirup.
253. The Germination of Seed Corn.
254. Cucumbers.
255. The Home Vegetable Garden.
256. Preparation of Vegetables for the Table.
257. Soil Fertility.
258. Texas or Tick Fever and Its Prevention.
259. Experiment Station Work—XXXV.
260. Seed of Red Clover and Its Impurities.
262. Experiment Station Work—XXXVI.
263. Practical Information for Beginners in Irrigation.
264. The Brown-tail Moth and How to Control It.
266. Management of Soils to Conserve Moisture.
267. Experiment Station Work—XXXVII.
268. Industrial Alcohol: Sources and Manufacture.
269. Industrial Alcohol: Uses and Statistics.
270. Modern Conveniences for the Farm Home.
271. Forage Crop Practices in Western Oregon and Western Washington.
272. A Successful Hog and Seed-corn Farm.
273. Experiment Station Work—XXXVIII.
274. Flax Culture.
275. The Gipsy Moth and How to Control It.
276. Experiment Station Work—XXXIX.
277. The Use of Alcohol and Gasoline in Farm Engines.
278. Leguminous Crops for Green Manuring.
279. A Method of Eradicating Johnson Grass.
280. A Profitable Tenant Dairy Farm.
281. Experiment Station Work—XL.
282. Celery.
283. Spraying for Apple Diseases and the Codling Moth in the Ozarks.
284. Insect and Fungous Enemies of the Grape East of the Rocky Mountains.
286. Comparative Value of Whole Cotton Seed and Cotton-seed Meal in Fertilizing Cotton.
287. Poultry Management.
288. Nonsaccharine Sorghums.
289. Beans.
290. The Cotton Bollworm.
291. Evaporation of Apples.
292. Cost of Filling Silos.
293. Use of Fruit as Food.
294. Farm Practice in the Columbia Basin Uplands.
295. Potatoes and Other Root Crops as Food.
296. Experiment Station Work—XLI.
298. Food Value of Corn and Corn Products.
299. Diversified Farming Under the Plantation System.
301. Home-grown Tea.
302. Sea Island Cotton: Its Culture, Improvement, and Diseases.
303. Corn Harvesting Machinery.
304. Growing and Curing Hops.
305. Experiment Station Work—XLII.
306. Dodder in Relation to Farm Seeds.
307. Roselle: Its Culture and Uses.
309. Experiment Station Work—XLIII.
310. A Successful Alabama Diversification Farm.
311. Sand-clay and Burnt-clay Roads.
312. A Successful Southern Hay Farm.
313. Harvesting and Storing Corn.
314. A Method of Breeding Early Cotton to Escape Boll-weevil Damage.
315. Progress in Legume Inoculation.
316. Experiment Station Work—XLIV.
317. Experiment Station Work—XLV.
318. Cowpeas.
319. Demonstration Work in Cooperation with Southern Farmers.
320. Experiment Station Work—XLVI.
321. The Use of the Split-log Drag on Earth Roads.
322. Milo as a Dry-land Grain Crop.
323. Clover Farming on the Sandy Jack-pine Lands of the North.
324. Sweet Potatoes.
325. Small Farms in the Corn Belt.
326. Building Up a Run-down Cotton Plantation.
328. Silver Fox Farming.
329. Experiment Station Work—XLVII.
330. Deer Farming in the United States.
331. Forage Crops for Hogs in Kansas and Oklahoma.
332. Nuts and Their Uses as Food.
333. Cotton Wilt.
334. Experiment Station Work—XLVIII.
335. Harmful and Beneficial Mammals of the Arid Interior.
337. Cropping Systems for New England Dairy Farms.
338. Macadam Roads.
339. Alfalfa.
341. The Basket Willow.
342. Experiment Station Work—XLIX.
343. The Cultivation of Tobacco in Kentucky and Tennessee.
344. The Boll Weevil Problem, with Special Reference to Means of Reducing Damage.
345. Some Common Disinfectants.
346. The Computation of Rations for Farm Animals by the Use of Energy Values.
347. The Repair of Farm Equipment.
348. Bacteria in Milk.
349. The Dairy Industry in the South.
350. The Dehorning of Cattle.
351. The Tuberculin Test of Cattle for Tuberculosis.
352. The Nevada Mouse Plague of 1907–8.
353. Experiment Station Work—L.
354. Onion Culture.
355. A Successful Poultry and Dairy Farm.
356. Peanuts.
357. Methods of Poultry Management at the Maine Agricultural Experiment Station.
358. A Primer of Forestry. Part II: Practical Forestry.
359. Canning Vegetables in the Home.
360. Experiment Station Work—LI.
361. Meadow Fescue: Its Culture and Uses.
362. Conditions Affecting the Value of Market Hay.
363. The Use of Milk as Food.
364. A Profitable Cotton Farm.
365. Farm Management in Northern Potato-growing Sections.
366. Experiment Station Work—LII.
367. Lightning and Lightning Conductors.
368. The Eradication of Bindweed, or Wild Morning-glory.
369. How to Destroy Rats.
370. Replanning a Farm for Profit.
371. Drainage of Irrigated Lands.
372. Soy Beans.
373. Irrigation of Alfalfa.
374. Experiment Station Work—LIII.
375. Care of Food in the Home.
376. Game Laws for 1909.
377. Harmfulness of Headache Mixtures.
378. Methods of Exterminating the Texas-fever Tick.
379. Hog Cholera.
380. The Loco-weed Disease.
381. Experiment Station Work—LIV.
382. The Adulteration of Forage-plant Seeds.
383. How to Destroy English Sparrows.
384. Experiment Station Work—LV.
385. Boys' and Girls' Agricultural Clubs.
386. Potato Culture on Irrigated Farms of the West.
387. The Preservative Treatment of Farm Timbers.
388. Experiment Station Work—LVI.
389. Bread and Bread Making.
390. Pheasant Raising in the United States.
391. Economical Use of Meat in the Home.
392. Irrigation of Sugar Beets.
393. Habit-forming Agents.
394. The Use of Windmills in Irrigation in the Semiarid West.
395. Sixty-day and Kherson Oats.
396. The Muskrat.
397. Bees.
398. Farm Practice in the Use of Commercial Fertilizers in the South Atlantic States.
399. Irrigation of Grain.
400. A More Profitable Corn-planting Method.
401. The Protection of Orchards in the Pacific Northwest from Spring Frosts by Means of Fires and Smudges.
402. Canada Bluegrass: Its Culture and Uses.
403. The Construction of Concrete Fence Posts.